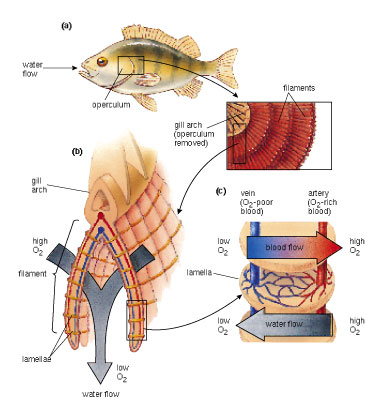
**Fish:**

**Gills and Gas Exchange—Countercurrent Flow**

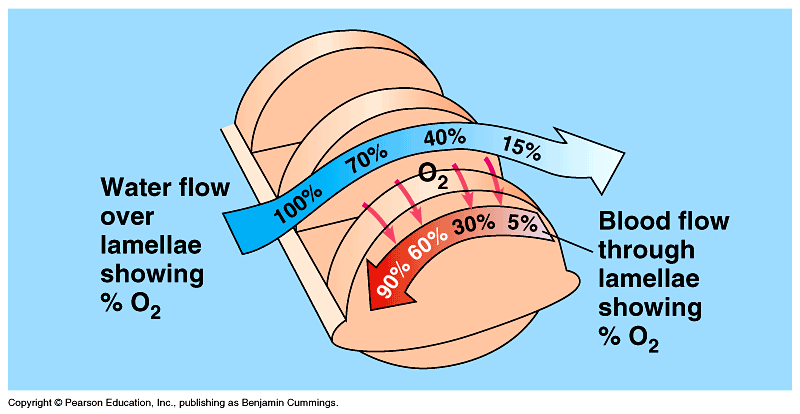
The gills of fish utilize countercurrent flow, a very effective mechanism for removing the maximum amount of oxygen from the water flowing over them (Fig. 1a). During countercurrent flow, two types of fluids (in this case blood and water) with different concentrations of one or more dissolved substances flow in opposite directions past one another. These fluids are separated by thin membranes. Countercurrent flow promotes diffusion of a substance (such as oxygen) down its concentration gradient from one fluid (water) to the other (blood).

Fish gills consist of a series of filaments supported by bony gill arches (Fig. 1b). Each filament is covered with thin folds of tissue called lamellae. Blood flows across each lamella within a dense network of capillaries. Within each lamella, countercurrent flow enhances diffusion by maintaining a concentration gradient of oxygen between the water (which is relatively high in oxygen) and the blood (lower in oxygen). As shown in Figure 1c, water is deflected over the lamellae in a direction opposite the flow of blood in the capillaries. Thus, the most highly oxygenated blood is brought close to the water that is just entering the gills and that has an even higher oxygen content than the blood. As the water flows over the lamellae, gradually losing its oxygen to the blood, it encounters blood that is also increasingly low in oxygen. In this way, the gradient encouraging oxygen to move from the water into the blood is maintained across all the lamellae. Countercurrent flow is so effective that some fish extract 85% of the oxygen from the water that flows over their gills.

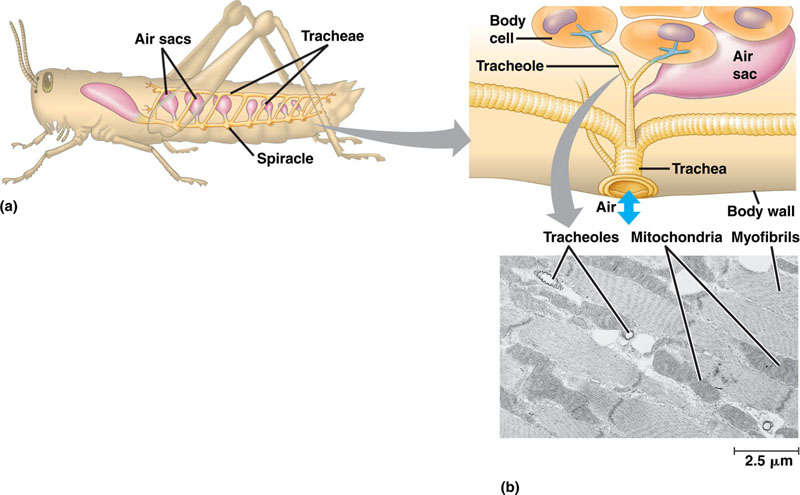


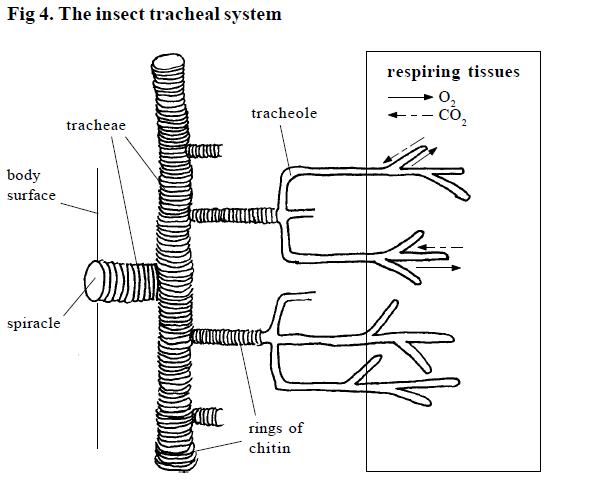
***Figure 1* The gill and countercurrent flow**

**(a)** The gill reaches its greatest complexity in the fish, where it is protected under a bony flap, the operculum. A one-way flow of water is maintained over the gill by pumping water through the mouth and out the opercular opening. **(b)** Each filament is composed of a series of platelike lamellae densely supplied with capillaries. Water is deflected across the gill filaments so that it flows directly across each lamella, as shown in part (c). **(c)** Countercurrent flow occurs across each lamella. Water highest in dissolved oxygen encounters the most highly oxygenated blood. As the water loses its oxygen to the blood, it flows past blood that is increasingly low in oxygen, so the gradient encouraging oxygen to move into the blood is maintained.



Insects





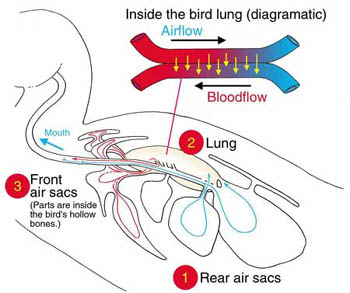


**canna lilly skipper larva is transparent**





**BIRDS**



Air sacs - membranes 